



PSLV-C33 IRNSS-1G



PSLV-C33



PSLV-C33 at the First Launch Pad

The Polar Satellite Launch Vehicle, in its thirty fifth flight (PSLV-C33), will launch IRNSS-1G, the seventh satellite of the Indian Regional Navigation Satellite System (IRNSS) into a Sub-Geosynchronous Transfer Orbit (Sub-GTO). The launch will take place from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. As in the previous six launches of IRNSS satellites, PSLV-C33 will use 'XL' version of PSLV equipped with six strap-ons, each carrying 12 tons of propellant.

This is the thirteenth time 'XL' configuration is being flown. Besides launching six IRNSS satellites, PSLV-XL has also launched many other spacecraft including India's Mars Orbiter spacecraft, the multi-wavelength observatory ASTROSAT, Radar Imaging satellite RISAT-1 and the Communication satellite GSAT-12. This apart, PSLV-XL has successfully placed five satellites from United Kingdom into orbit in a single commercial mission. Through these launches, PSLV has repeatedly proved its reliability and versatility.

PSLV-C33 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N ₂ O ₄)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass (T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

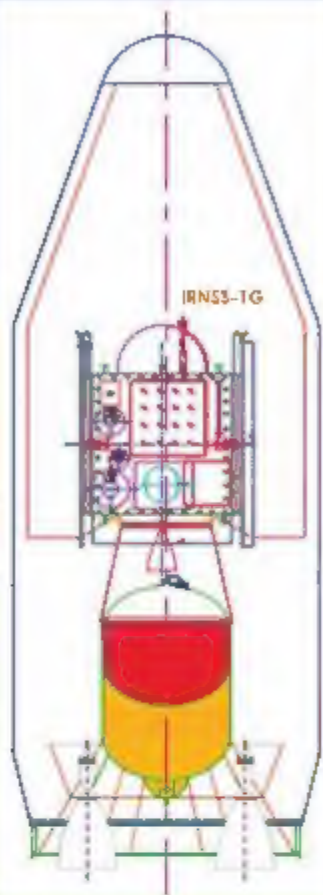
HTPB : Hydroxyl Terminated Poly Butadiene

UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate

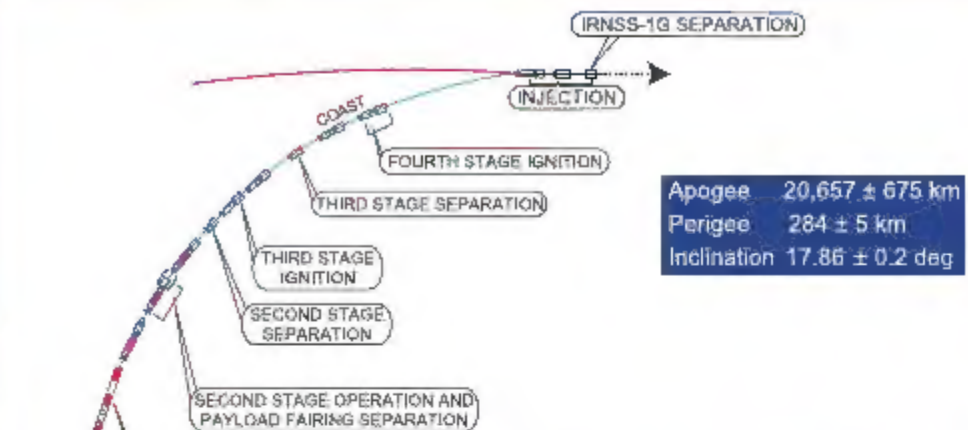
N₂O₄ : Nitrogen Tetroxide

MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C33



IRNSS-1G in PSLV-C33 Envelope



Event Name	Time after LH-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1G Separation	20min 16.02sec	497.007	9506.45
Fourth Stage Cut-off (Injection)	19min 42.02 sec	446.675	9546.21
Fourth Stage Ignition	11min 13.2sec	192.225	7723.64
Third Stage Separation	11min 3.2 sec	190.632	7725.74
Third Stage Ignition	4min 23.24 sec	132.316	5373.49
Second Stage Separation	4min 22.04 sec	132.069	5373.69
Payload Fairing Separation	3min 16.92 sec	112.610	3643.63
Second Stage Ignition	1min 50.32 sec	65.823	2394.65
First Stage Separation	1min 50.12 sec	65.653	2395.16
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	39.887	3059.61
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	23.751	1449.94
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	23.623	1445.17
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.694	616.32
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0.00	0.024	451.89

PSLV-C33 Typical Flight Profile

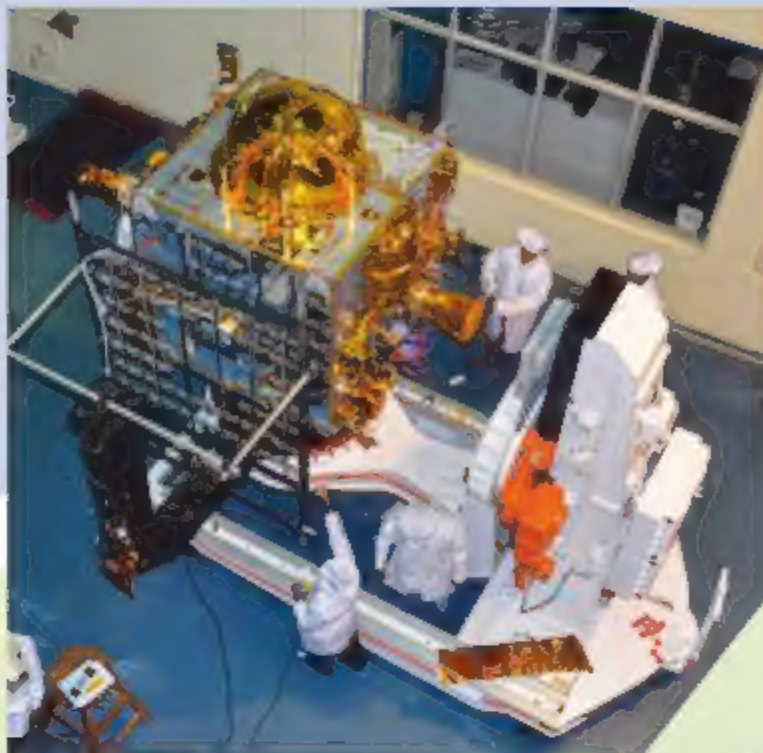


PSLV-C33 core stage integrated above the launch pedestal



Second stage of PSLV-C33 being prepared for vehicle integration

IRNSS-1G



IRNSS-1G being prepared for a prelaunch test

IRNSS-1G is the seventh navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A, 1B, 1C, 1D, 1E and 1F were launched by PSLV-C22, PSLV-C24, PSLV-C26, PSLV-C27, PSLV-C31 and PSLV-C32 in July 2013, April 2014, October 2014, March 2015, January 2016 and March 2016 respectively. Like all other IRNSS satellites, IRNSS-1G also has a lift-off mass of 1425 kg. The configuration of IRNSS-1G too is the same as IRNSS-1A, 1B, 1C, 1D, 1E and 1F.

The two solar panels of IRNSS-1G consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference to the satellite. Special thermal

control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1G maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.

IRNSS-1G will be launched into a sub Geosynchronous Transfer Orbit (sub-GTO) with a 284 km perigee (nearest point to Earth) and 20,657 km apogee (farthest point to Earth) with an inclination of 17.86 deg with respect to the equatorial plane.

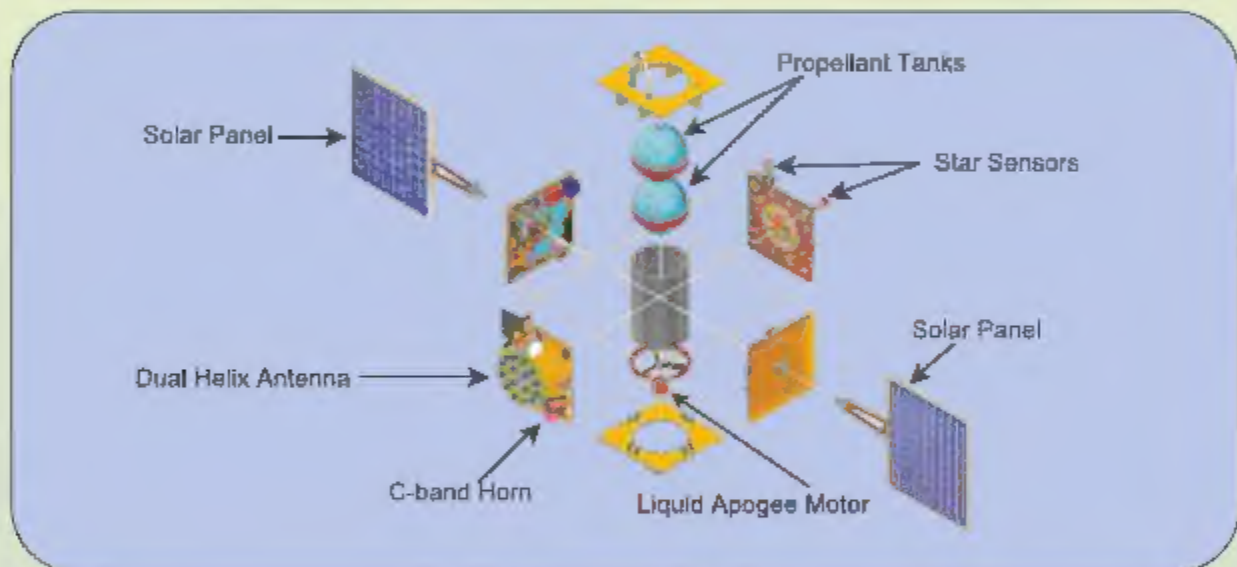
After injection into this preliminary orbit, the two solar panels of IRNSS-1G are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of one manoeuvre at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the geostationary orbit at 129.5 deg E.



IRNSS-1G in clean room at SDSC SHAR

IRNSS-1G Salient features

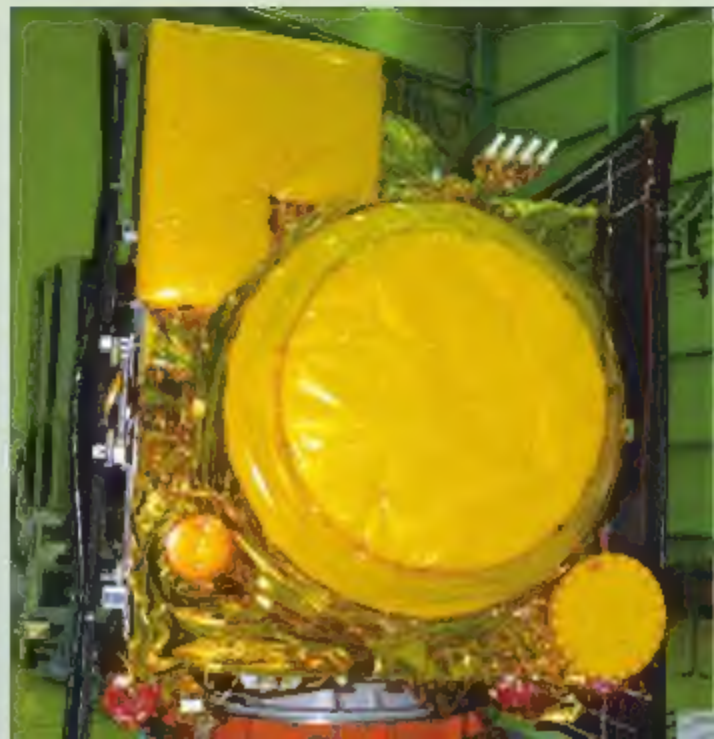
ORBIT	Geostationary, at 129.5 deg East longitude
LIFT-OFF MASS	1425 kg
DRY MASS	598 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation Input from Sun and Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	12 years



IRNSS-1G Disassembled View

PAYLOADS:

Like its other IRNSS predecessors, IRNSS-1G also carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1G will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1G consists of a C-band transponder which facilitates accurate determination of the range of the satellite.



IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is the primary service area of IRNSS. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS), which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS comprises a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS-1A, 1B, 1C, 1D, 1E and 1F, the first six satellites of the IRNSS constellation, have already started functioning from their designated orbital slots after extensive on-orbit test and evaluation to confirm their satisfactory performance.

The IRNSS Signal-in-Space Interface Control Document (ICD) for SPS version 1.0 was released in the official ISRO website <http://irnss.isro.gov.in> in October 2014. The information for a user to acquire, track and utilise the SPS navigation signals are available in the ICD.

With the operationalisation of six satellites, proof-of-concept of an independent regional navigation satellite system over India has been demonstrated for the targeted position accuracy which is much better than 20 mtrs over 24 hours of the day. With the launch and operationalisation of IRNSS-1G, the seventh in the constellation, the completion of IRNSS constellation will be achieved.

IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.



ISRO Navigation Centre at (INC) at Bialalu, the Nerve Centre of the IRNSS ground segment

Currently, IRNSS ground segment is operational on 24/7 basis with 13 Indian Range and Integrity Monitoring Stations (IRIMS), one IRNSS Network Timing Centre (IRNWT), one ISRO Navigation Centre (INC) and one Spacecraft Control Facility (SCF) with its data communication network. The entire ground segment with two more IRIMS and one each of IRNWT, INC and SCF is planned to be completed in future.

Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Vehicle tracking and fleet management
- Terrestrial navigation aid for hikers and travelers
- Disaster Management
- Integration with mobile phones
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers



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